Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF MICROSCOPISTS.

NINTH ANNUAL MEETING.

ANNUAL ADDRESS OF THE PRESIDENT:

BACTERIA AND DISEASE.

THOMAS J. BURRILL, Ph.D., F. R. M. S., Champaign, Ill.

Fellow Members of the American Society of Microscopists:

I am to address you to-night upon a class of living things of whose very existence nothing was known nor could have been known except by the aid of the microscope. Since the latter, though now perhaps the most nearly perfect instrument of man's mechanism, is of recent origin, the minute organisms of which we speak are new to human knowledge. In fact no considerable attention was paid them until within the memory of the majority of the members of our society,—about thirty-five years ago. The classical researches of Schwann, of de la Tour, of Pouchet, and especially of Pasteur, upon fermentation and spontaneous generation at length caused careful studies to be made upon these the least in size of nature's animated existences. Then the observed evidences that the bacteria held some relation to disease (first seriously suspected in the case of anthrax or splenic fever in cattle, afterward demonstrated to be the cause of this dangerous malady by Pasteur and Koch) brought them prominently into notice. Now, for twenty years the literature upon the nature and effect of bacteria has been steadily growing, until to day it is scarcely possible for any one man to keep track of the voluminous pages devoted to them. It is to these organisms that I now invite your attention.

It is well known that if we leave meat broth in a warm place, after a few hours an ill-scented odor becomes perceptible. We say the material has spoiled, is tainted, or that putrefaction has commenced. The filtered liquid is originally perfectly clear and limpid, but under the conditions named becomes opalescent and finally milky or turbid. If now we examine a drop of the material under a power of three hundred or more diameters, we find the field of the microscope alive with minute colorless organisms, perhaps of various shapes, and, notwithstanding their minuteness, differing considerably in size; but marvelously endowed with the power of motion.

In surprise and admiration we gaze at the wondrous spectacle,—a busy maze of motion. We see the living things rolling over and over, spinning like a top, whirling like a windmill, freely dancing up and down in the thin film of the liquid pressed between two pieces of flat glass, now pausing as for rest, or gently swaying back and forth as if attached by an invisible filament at one end, now off like a flash, now sailing with stately mien and dignified bearing through the ocean beneath our eye. It is impossible to avoid askasking ourselves: Whence this teeming life of the microscopic world? The first sight is enough to make us want to know more of the tiny population of this newly discovered fairy-land. What are these busy creatures? What of their origin, of their structure, of their modes and terms of life, of their relations and effects?

A hundred questions press themselves upon us for answer; a thousand problems await solution—questions and problems springing, perhaps, at first from a stimulated curiosity, but destined to affect the march of human progress; to prove great factors in the evolution of human history; to contribute to the health and happiness of man; to conspicuously aid him in gaining grasp and mastery of the facts and forces of earth, and so ultimately to secure for him the imperial dominion announced in the beginning by the self-same Creator of the little organism, and of rational, thoughtful, God-like man. Thanks to the marvelous instrument, which, in its later day evolution of perfection, renders possible the kind of work that brings us together for mutual gain and encouragement, many of the secrets of this tiny but thronging population of an otherwise invisible world have been known.

The revelations are astonishing; the results surpass the widest reach of imagination, and penetrate to foundations never dreamed of in philosophy. We have come to know that, with other things as they are in the world, the bacteria and their allies are absolutely indispensable to the physical existence of man. Without them the earth would be as uninhabitable as the volcanic, rock-riven face of the moon. Destroy them now, and the fertile soil upon which we depend for food would speedily lose its capacity to support green vegetation.

All organic substances would continue substantially as they are, or at least as they must be without the processes of fermentation and decomposition. The richness of the tillable soils is largely due to partially decomposed or decomposing matter. Deprive our fields of this, and they become barren wasts, sterile and inhospitable clays and sands to the vision of their once prospeous and happy, but now doomed and perishing occupants. It is even probable that without the aid of the bacteria normally living in our own bodies some of our necessary physiological processes would cease, and we should perish in another way in consesquence of the withdrawal of these tiny workers.

I beg pardon of those to whom the thought is an unpleasant one, and by no means wish to insinuate that the tooth-brush has been neglected; but the fact is, any one of us can furnish from his mouth material for the microscope as teeming with life as was the drop of meat broth with which we began. The digestive tract throughout is a veritable hot-bed of bacteria. Whether or not we are our brother's keeper, we are keepers of a brotherhood whose individuals count into the thousands and millions. Neither are these idle tenants and guests. They sleep not, nor rest. If there for good we may depend upon their presence and activity; if for evil we must make the best of it, striving to gain dominion here as elsewhere.

It possibly may be more agreeable to know that these living organisms are not commonly found in the blood or other fluids of the body in health. They more or less abound upon the exterior surfaces, even the eye having its occupants, but the skin and the covering of the mucous surfaces, when intact, rigidly exclude them from the inner tissues.

It may be said in passing that we are also indebted to the bacteria and their allies for various preparations of food, so called yeast bread, salt-rising bread, cheese, fermented and distilled liquors, certain salads and flavoring materials; they are the active agents in various processes in the arts—in all those in which fermentation and decomposition of organic matter form an essential part.

But if we are indebted in many ways to the activity of these minute organisms, indebted indeed to them for life and health, we are learning to score up against them long and large accounts upon the other side of the ledger. They are pre-eminently destroyers. Their office is to reduce, to tear down. We are obliged to protect many valued substances in some way or other from their ravages. All the processes of food preservation, as salting, smoking, drying, canning, etc., are directed to this end. It was formerly taught that fruits, vegetables, meats, etc., were put into hermetically sealed vessels to exclude the oxygen of the air as the destroying agent. We now know that cotton wool as a stopper, through which the strained air freely passes, is as effectual as a porcelain lid with rubber fitting in the preservation of putrescible substances.

In either case we must first see that the living organisms are killed by heat or otherwise, and then that these latter, not the elements of the air, are kept out. A cotton plug previously subjected to a temperature several degrees above that of boiling water, will effectually do this, and boiled fruits, meats, etc., will remain sweet forever while thus inclosed. An experiment of this kind properly carried out teaches most valuable lessons as to common phenomena of nature, to those willing and able to learn from such instructions. Without living organisms milk and cooked vegetables do not sour, the expressed juices of fruits do not yield alcohol, neither piles of green vegetation nor the accumulation of stables becomes hot, wood does not decay, animal flesh does not putrefy, butter does not become "strong," water in tanks is not tainted, rivers are never sewers of pollution and offense. Such negatives may be indefinitely extended, and when we come to count the loss of valuable property through kindred processes by the agency of microscopic beings, the total destruction swells to prodigious proportions.

Should we stop here, the account against the bacteria and their associates forms upon the debit pages innumerable columns, whose footings no one can adequately realize. But we have a still more serious charge against these liliputian foes. They are the agents of disease and death among plants, animals, and men. No fanatic among the microscopists has ventured to assert that all diseases are caused by bacteria; but the truth is, as we learn more and more about them and their effects, we find in the list of maladies more and more of these that are parasitic in origin.

All communicable diseases (not including hereditary ones must be put down in this class, besides many that are not passed from individual to individual in the ordinary course of life. What an enumeration may now be made! The long roll inscribed against the sky would be more dismal and threatening to the vision of suffering mortals than any blackness of natural clouds, carrying evidence of the worst meteorological commotions. We daily walk through vicissitudes of danger. If we are not often injured, it is because our bodies are so wonderfully contrived to resist attack, and that our physiological powers are greater than those of our enemies. Fortunate, indeed, is it for us in our day that we have succeeded in offering battle so successfully. Man is still, in some circumstances and conditions, cut down as the grass; as a flower of the field, so he perisheth; but it does not require much historical research to show that the simile was emphatically just in former times.

What were the calamitous visitations, ofttimes attributed to the anger of the gods, by which whole tribes and people were swept from the earth? What was the plague described by Gibbon, which during fifty years in the sixth century destroyed a large proportion of the population of the Old World? What was the black death, which is said to have annihilated one third of the people of Europe, in the fourteenth century? What of the depopulation of London by the plague two hundred years ago? What wholesale slaughter occurred among the original inhabitants of North America by smallpox introduced from across the seas!

This latter disease, and others like it, still have their victims, but thanks to the experimental and inductive science of our century, relief has come to the civilized world. Instead of ascribing these awful calamities to the visitations of Providence, and meekly submitting to the inevitable, we have come to recognize that even plagues and pestilences are subjects of scientific investigation, and that effects, as we observe them, have adequate and comprehensible causes. Thanks very largely to the microscope, we are now able to ascertain the causes of communicable diseases. Many of them have been found, and we are patiently but certainly gaining reliable information day by day, by which we may be trustfully guided in our struggle for existence against foes no longer invisible and unknown.

We of the American Society of Microscopists, as well as all other associations whose main object is to foster research into the domain of things too minute to be seen with unaided eyes, may well take pride in our matchless instrument, and have ready abundant excuse for traveling annually to our place of meeting, to take counsel together concerning its improvement and all that relates to its practical and beneficent revelations.

Having thus presented our subject, let us turn for a brief discussion of some of the points continually arising in the literature of our topic.

First.—What are bacteria? Nothing need here be said as to their appearance, structure, or place in a classification of natural objects; but we may especially ask, whence their origin? It is certainly important in our discussion of the origin and occurrence and recurrence of disease that we should understand as fully as possible all the circumstances and conditions connected with the beginning and distribution of the disease agents. Let it be taken as scientifically settled that living organisms do not spontaneously come into existence through some transformation of inorganic materials. We need not say this never has occurred, nor, in fact, that it may not, under some peculiar circumstances or conditions, occur now; but evidence is so abundant that the process does not take place in the usual course of affairs, that we may exclude it altogether in our practical relations with the subject. We have then only to ask, are bacteria independent, autonomous existences, or are they temporary modifications of other living things? It has been held by competent observers, that in certain conditions, various species of fungi become so modified in their growth as to assume, temporarily, the form and other characteristics of bacteria. Various accounts have been given, in scientific publications, of the observations upon such changes. These, however, are mostly by men not specially familiar with the actual development of the organisms in question. We positively know that some of these assertions are untrue, for when less fallible means are employed in experiments of the same kind, other results are uniformly obtained. By many, however, the idea is not entirely abandoned. During the last year, in a reputable scientific publication[*] in France, a series of articles, based upon elaborate and extensive experiment and observation, have appeared in which the author endeavors to show that the so-called microbes (bacteria) are nothing more than vegetative states of a common mould (Penicillium). In a similar way, but apparently with more reason, a well-known German investigator[†] announces the derivation of yeast plants (allied to bacteria) from the smut fungi (Ustilagineæ).

Recently a paper has appeared in our own country in which the author, upon theoretical grounds, concludes that bacteria owe their origin to the metamorphosed tissues of animals; a view previously put forth. A sharp discussion occurred two months since in the French Academy of Medicine,[‡] between Pasteur and Béchamp, the latter holding the ground that microbes of the various genera and species are transformed somethings which he calls microzymas. These latter, according to Béchamp, are definite associations of chemical molecules, existing since the creation of matter, and capable under proper conditions of becoming transformed into low and simple forms manifestly endowed with life and its activities. It is not the older idea of spontaneous generation, for the microzymas are special organizations already possessing the power and potency of life, but quiescent or latent. In the open meeting Pasteur combatted Béchamp's results, the hot discussion reminding one of several similar ones in which it will be remembered the former distinguished contestant came off victorious. But a commission has been appointed to examine into the matter of Béchamp's microzymas and we shall before long know the opinion of the examiners.

---

[*] *Journal de Micrographie*, x. (1886), p. 123 *et seq.*
[†] *Brefeld. Unsuch. ü. Hefenpilze, Leipsig*, v. (1883).
[‡] *Science*, VII. (1886), p. 521.

We have nothing to say against such speculation, even when founded upon hypothetical deductions, but must continually ask ourselves, what is the evidence of experiment? If this seems to teach now this, now that, in a question of this kind, let us re-examine our methods, resting assured that error lurks somewhere.

It is wonderful how convincing the recent methods of pure, uncontaminated cultures of the lowest and simplest organisms have become. One may easily acquaint himself with these processes, and without much apparatus besides his microscope may soon form an opinion for himself as to whether bacteria ever arise from anything besides pre-existing parent forms, each, after his kind, in foreordained succession, as immutable as in the case of oaks or of horses. This, of course, does not exclude some difference in size, form, and method of growth, on account of difference in conditions. Who has not seen submerged leaves on plants dissected into feathery divisions, while the aërial ones on the same stems rising above the water are entire or slightly lobed? Any one agriculturally observant, who has traveled through New England and the States of the Mississippi valley, must have noticed the difference in the size and appearance of maize or Indian corn—in the latter two to four times the height seen in the former regions. Nature everywhere is prodigal in variety of form, size and appearance.

We must expect something of the same kind among our microscopic growths; but, allowing for this, the concurrent testimony of the best and most expert investigators now is that bacteria are true and distinct existences, having real genera and species, propagated like other living things from individuals to individuals,—if we cannot so properly say—owing to their method of simple division, one into two, two into four, etc.,—from parent to offspring.

Second.—Do bacteria cause disease? Admitting the exisence of bacteria, and the perpetuity of their specific forms, the proof that they have anything to do with the cause of disease is constantly challenged. It would almost seem that men are determined not to accept proof in this case, however strong it may be. Large numbers of the medical profession appear to pride themselves upon not accepting "new fangled ideas," whatever the basis of evidence. Quote your authority to them on this matter of parasitism and the sufficient reply is, "Oh, he is a bacteria crank!"

Now, I have profound respect for the profession of medicine and for the men who laboriously and conscientiously practice the healing art, whether they accept any special ideas held by myself or not; but I respectfully submit that one who personally and experimentally knows nothing upon a given and particular subject, no matter what may be his information upon other matters, or how broad his knowledge or great his fame, is not a competent judge upon the special thing of which he is confessedly ignorant.

Certainly too many medical men, as well as others, have not recognized this apparently axiomatic truth. Witness the discussion upon the etiology of disease in the meeting of the American Medical Association at St. Louis, in May, 1886. The "microscopic bugs," according to one speaker, have received of late altogether too much credit as causes of disease! It is ever thus. Old ideas die hard. We hear a good deal, fortunately not so much as formerly, about the conflict of science and religion, and we cannot disguise the fact that there is a conflict, deep and earnest, ofttimes sore; but it is a conflict, again, between the new and the old—not between science and religion, nor of truth or about truth, but of men's changing ideas of truth.

Among those whose business it is to deal with the therapeutics of disease, we find more and more of the younger men intelligently accepting the bacterial etiology of disease. By the time that these become in general, as they now are in a hopeful part, the professors in the colleges, students will have no further hesitation in believing their senses and in adopting the testimony of trustworthy experts.

It would carry me too far to attempt to detail here, even for a single case, the convincing and indisputable proofs that bacteria do cause disease, neither is it necessary in this presence; for among those whose inclinations and opportunities have led to the satisfying use of the microscope, and to the examination of the abundant literature connected therewith, there is no doubt upon the subject, there is no need of a repetition of the evidence.

We must not, we do not, by any means ascribe all forms of disease conditions to parasitism. Our corporeal machinery is altogether too complicated, too delicately adjusted and balanced, to run smoothly forever without friction and jars from internal and inherent failings. The vicissitudes of circumstances and of conditions are too varied and vigorous to count for nothing upon our sensitive organism, and the influence of mind on body is by far too great to.be passed unheeded as a factor in disease; but we may fearlessly assert without reservation of any kind that all truly infectious and contagious diseases are due to parasites of some kind.

Each of these maladies has as its immediate cause a living thing distinct from the body itself, capable of independent growth under the proper conditions outside of the body, possessing the power of self-perpetuation or reproduction and multiplication, endowed with specific characteristics, and animated and controlled by a spark of that same mysterious quality or substance—whichever it is—which distinguishes ourselves from the inorganic, dead clods of earth,—the quality or substance known to us as vitality or life. Where this last comes from, and how it is associated with the minute speck revealed by our microscope, science cannot tell. Homogeneous immersion lenses fail utterly to give us instruction in this important particular.

Not all communicable diseases are, however, due to bacteria. Scabies, or "the itch" of the olden time, is in consequence of an eight-legged mite; some of the mold-like and yeast-like plants infest, to our discomfort, the human body; trichinæ and numerous other worms are causes of disease, and recently it appears to have been established that malaria is to be charged to the account of minute amœboid animals, making tenements of our blood corpuscles.

But making these and other exceptions, the bacteria may yet be said to be *the* disease producers, *the* parasites of contagious diseases, as well as many maladies not considered communicable. Whether tuberculosis (consumption) is always directly derived from contagion, that is, always from diseased individuals, is not settled, though that the morbid processes are due to *Bacillus tuberculosis*, a specific and now well-known organism, ought to be universally accepted. The statistics of the hospitals* do not yet show that this disease increases in consequence of the admittance of tuberculous patients.

The report of a committee of the *Société Médicale des Hopitaux*,† France, gives the number of actual observations as 439. Of these, 213 were favorable to contagion and 226 hostile, as understood. Of the first series there were 107 cases between married couples, 71 between near relatives, 18 from child to parent, 16 between distant relatives, and one from man to dog.

Whether or not tuberculosis arises in any other way than as a communication from the diseased to the healthy, it is positively a virulently contagious malady, and the sooner this is recognized the better for human life and sanitary science. The disease can, at any time, be communicated to healthy animals by inoculation, and this from perfectly pure cultures of the specific microbe. Keep this latter strictly away and we shall suffer no more from the peculiar and dreadful scourge which now inflicts such untold misery upon our race. As we come to know more about the various methods by which the virus is conveyed, we shall be better able to escape its contagion. It is now thoroughly demonstrated that tuberculosis may be conveyed through the food—a method which has obscured, no doubt, the real contagious character of the disease.

We are also speedily coming to recognize that all acute suppurative processes are chargeable to bacteria. What an era of progress in surgery is this of our day! What inestimable blessings to the maimed and unfortunate has come since Lister first experimented with his cleansed instruments and antiseptic dressings! What needless pain has been spared, and how many lives have been saved by the progress of surgery since the memorable date of 1865! An operation (ovariotomy) which, previous to that time, was considered exceedingly dangerous—twenty per cent. of deaths in spite of the highest attainable skill—has been performed one hundred and thirty-nine times in the two years ending December, 1885, without a single death, by Lawson Tait, of England, and others are having almost as marvelous success.

It used to be said when skin eruptions occurred, when boils,

**Comptes Rendus*, CII. (1886), p. 301.

†*Medical News*, XLVIII. (1886), p. 378.

felons, abscesses, carbuncles, etc., affected the suffering, that "the blood was out of order," and various and powerful were the prescriptions therefor. Perhaps the most of us can remember the regular sulphur and molasses treatment every spring time to dissipate the evil accumulations of inactive winter. Even now it is supposed by many that irritants like croton oil, applied to the skin, produce suppuration, but investigations show that in none of these and similar instances is pus formed without micro-organisms as the true agents.

Again, we have come to understand that many diseases not commonly conveyed from the sick to the healthy are directly connected with the food and water consumed. Multitudes of cases are on record where sickness has been attributed to canned vegetables, preserved meat, fish, milk in various conditions, edible mushrooms, etc.

Statistics gathered in Swabia* show in half a century four hundred cases of sickness and one hundred and fifty deaths from sausage poison, presumably not trichinæ. An epidemic in the Volga district that spread terror throughout Europe a few years ago was traced to the preserved fish used as food.

Abundant examples are furnished in our own country in every community. Last year numerous cases of poisoning by cheese were reported in Michigan, and now word reaches us of like effects from the use of ice-cream. Recently in Wilhelmshaven,† a sea-port town of North Germany, a large number of people were made sick after eating edible clams taken from the waters of the harbor, into which was poured the sewage of the city. Several deaths occurred. These mussels taken from pure water are perfectly acceptable articles of food, but those from the sewage-contaminated areas were found to be virulently poisonous, killing rabbits in from two to ten minutes. These and similar results are due to the microscopic living agents of fermentation and putrefaction, either by their direct action when taken into the stomach, or through the accumulations of poisons produced by them in the decomposing materials. Milk is peculiarly liable to fermentative changes and hence dangerous as food when improperly handled.

---

* *Popular Science Monthly*, XXIX. (1886), p. 250.
† *Science*, VII. (1886), p. 175.

Let it not, however, be understood from this that all fermented products are necessarily unhealthful. It is only when certain specific changes take place that danger exists. It behooves us to find out what and why.

But the most dangerous of such contaminations are those finding their way into drinking water. Among the most deplorable records in the tables of sanitary science are those of typhoid fever,—certainly a parasitic disease, and almost wholly communicated through the agency of water. It is stated* that there are annually in the United States twenty-five thousand deaths from this wasteful disease, representing one million five hundred thousand cases. The one million two hundred and fifty thousand sick who recover lose at least six weeks from the activities of life, besides the cost entailed by attendants, leaving out the miseries of the sick chamber. If we count the loss in money by reason of incapacity of the sick to labor and the expense of attendance together, at one dollar per day, we shall have for those who survive an aggregate annual financial loss of $52,500,000, all of which ought to be avoided. Possibly our present knowledge is not sufficient, even if rationally and carefully used, to fully extirpate this appalling malady; but we are positive that the great highway to the requisite further information is open, and scientific investigation is competent to reach the merciful end. In Philadelphia, last year, there were reported six hundred deaths from typhoid fever,—at least three thousand cases,—upon which an editor of a medical journal† remarks: "It would seem that no more effectual method could be devised for the generation and introduction of noxious gases than exists even now in thousands of houses in this city." The violent epidemics of this disease in Brooklyn, N. Y., and of this or something similar in Plymouth, Pa., are well remembered.

In my own town, of 10,000 inhabitants, a small, open stream of water, almost failing in midsummer, receives the sewage and filth inevitably collected in its course through the suburbs of the place. Cows are permitted to run at large upon the wide open commons and to drink at will from this polluted water. No evidence is now needed that milk from cows drinking the water carrying the germs of typhoid fever may communicate the disease. This is an incontestable fact. Sometime, I fear when it is too late, our people will recognize the awful danger that attends a risk of the kind now pointed out; and yet our State Board of Health rates the town among the best in its sanitary condition.

---

* *Science*, VII. (1886), p. 568.
†*Medical News*, XLVIII. (1886), p. 687.

Third.—How do bacteria cause disease? In all this talk about bacteria as disease agents, we are apt to think of them as specially distinct and different from all other living things, perhaps as endowed with some venomous properties like poisonous snakes among animals. But the fact is, these microscopic organisms are simple plants, living and dying, growing and multiplying, under conditions as circumscribed and laws as immutable as those which limit and govern other vitalized beings or things. They are far removed from anything that can be called malicious. They heed not the ruin wrought, but, obeying the impressed law of vegetative growth, simply appropriate suitable food when and where it is supplied to them. Having no means of locomotion save upon a microscopic scale, and this only in the case of certain species, they are subject, as to distribution, to the natural forces of air and water currents, gravitation, or the movements of other living things. They are destroyed by heat, in their vegetative condition never surviving that of boiling water continued some minutes (as spores resisting somewhat higher temperatures for longer periods), poisoned by various chemical substances, and killed at length from exposure and starvation. The bodies of living plants, animals, and men are by nature carefully protected against these unarmed foes by an epidermis or skin usually impenetrable by them, by specially and wonderfully constructed guards to prevent their entrance to vulnerable openings,—as the hairs moistened with mucus in the human nose, and the moistened vibrating cilia of the epithelial cells lining the road to the lungs. They are checked or entirely overcome by the natural secretions, like the ethereal oils in plants (perhaps here for that very purpose), the acids of the stomach, and the strongly antiseptic bile of animals; or, finally, are beaten in the struggle for existence by the peculiar powers of vital resistance possessed in greater or less degree by all living things, plants as well as animals, man as well as bacteria.

Against such defences and barriers our minute, simply constructed, senseless bacteria must make their way if they are going to gain their own sustenance from living plants or animals. The fact is that most kinds of bacteria are never able to overcome these vital barriers. We hear it said, "Bacteria cannot be the cause of disease since they are about us and within us in great numbers in our best states of health." As well might it be said, animals will not eat flesh, since we know great pastures full of flocks and herds that cannot be made to touch it as food. Most species of bacteria are confined to a regimen of dead organic matter. They riot in the carcass of a dead animal that they were wholly unable to injure in the living state. Other species, still greater in number than those to be next mentioned, manage to grow and multiply on or in living things only when the ramparts of the latter are broken down, when the defences are weakened, when the ebb and flow of the vital current is by other means reduced or deranged. Bacteria that without help cannot get through the skin upon one's arm, may readily do so by the aid of croton oil or cantharides. Those which ordinarily cannot pass the ordeals of the stomach, may do so in cases when, by the untoward influences of unhygienic food, the latter fails to excrete its normal juices. Finally, certain species much fewer in number than the preceding, seem to have powers of invasion altogether surpassing the defences normally offered by many individuals. These are the organ isms of true contagions, like small-pox, scarlet and yellow fever, measles, and cholera. Yet even with these last the struggle is ever going on. In the worst epidemics certain persons remain unharmed, not because the disease producers are wanting, but because their physiological activities are more than matched by those of the exempt party. And the same person may offer far greater resistance to these destroyers at one time or in one condition than at or in another, just as he may to every other influence or thing. Let a man not accustomed to hard labor in the sun go into the meadow and attempt to swing a scythe all day, and what will be the probable result? Let him of the north change his habitation in summer to the tropical south, what may he expect?

Without further discussion we may say that certain kinds of bacteria cause disease by invading, against the provided defenses, the bodies of animals or plants and by physiological activities peculiar to themselves disturb those of the invaded or parasitized hosts. In some cases their detrimental influences are mainly mechanical. By multiplying and collecting in great numbers they form plugs in the blood vessels and impede the circulation. By similarly collecting in the air passages suffocation may follow. Others, like the bacilli of tuberculosis and typhoid fever, after gaining lodgment in the body, have a corrosive action by which the substance of the tissues is modified or destroyed, while still others give rise to chemical changes inimical to health. It has been found in certain cases, without, as well as within the living body, that organic compounds called *ptomaïnes* are formed (through the decomposing activities of special organisms), having physiological properties similar to those of the alkaloid poisons. There is surely nothing surprising in this. The alkaloid poisons like atropine and strychnine are products of plant physiology. Should we wonder that among the multitude of chemical changes set up by bacteria in organic bodies, some of these should result in poisons as deadly as those secreted by other plants? More recently it is announced that poisons are manufactured in the chemical changes produced by the forces of the living body itself. To distinguish these the name *leucomaïnes** has been given them by Gautier, their discoverer. Here again there is to my mind nothing improbable or contradictory to former thought. Green plants develop poisons, bacteria develop similar poisons as organic compounds; why need we wonder that we ourselves having wonderful vital powers over chemical changes may under some conditions and circumstances also give rise to poisonous products?

What concerns us most is that the poisonous ptomaïnes may be produced in materials intended for human food, and thus make untold mischief and suffering. A case of this kind undoubtedly occurred in the dried beef poisoning reported to this Society last year by Dr. Detmers.

Fourth.—How may diseases due to bacteria be avoided? It is to the answer of this practical question that the great and chief interest in investigations upon pathogenic bacteria is attached. Most people care little for the minute organisms themselves. They would rather never have any introduction to, or form anything like a practical acquaintance with, them or their effects. How are we to escape? is the cry. Would that the cry were louder! Happy for the human race when the danger is rationally apprehended—when men are aroused to the imperative importance of intelligently strengthening and assisting their natural defences, of directly and skillfully combating revealed and comprehended enemies, of scientifically and thoroughly protecting themselves! It can be done!

---

* *London Lancet*, April 24, 1886.

What has been accomplished within our memories gives a basis for abundant faith that much more is to be done. Man, not microbes, is to have dominion! We can only glance at the possibilities within our reach, at the accomplishments achieved. In the first place, it must be recognized that a knowledge of the causes of a disease is a great step towards prevention or cure. One may occasionally accomplish something fighting in the dark, striking at unseen foes, but it is awkward business at best and usually futile in result. The enemy once found, his habits and methods discerned, conquest may be assured and victory easy. It is fully time that we accept the parasitic doctrine of disease, that we believe in the revelations of our microscopes, that we recognize in bacteria and their allies the sought for enemies and that we marshal our forces against them.

When those whose professional business it is to deal with disease unite upon this ground and together in solid agreement help in the struggle, we shall make rapid advances toward the victory prophesied. When legislators and those in authority come to intelligently understand the duties devolved upon them from this same standpoint of bacteria and disease, we shall be better able as communities to baffle the invaders and spoilers. When individuals learn what to do and how to do it, the triumph must be near at hand. Families and communities must protect themselves against injuries and diseases from poisons in foods and drinks by better information in the matter of preparation and preservation, and by the rigid exclusion of dangerous germs. In the manufactories intelligent supervision must be demanded; in the markets faithful inspection and enforced purity rigorously insisted upon, and in the water supply especially, freedom from contamination insured.

Against the inroads of the recognized contagious diseases we have offered quarantine regulations, the isolation of the diseased, and the consumption by fire of the disease-carrying products, together with the means now known of prophylactic vaccination or inoculation and of germicidal sanitation and medication.

As illustrative examples I will conclude with the citation of two notable accomplishments in the prevention of diseases reckoned among the worst that afflict mankind. Taking for our information a paper written by George Higgin*, compiled from the correspondence of the *London Times*, let us examine the relation of cholera in Spain in 1885, to the water supplied to the different towns in which the disease occurred.

In Madrid, a city of 397,000 inhabitants, there was in 1865 an epidemic of cholera of a very malignant type. During the season there were sometimes from eight hundred to twelve hundred cases per day.

Last year the first case occurred May 20, and the total number of cases up to the end of September (when the disease gradually disappeared) was two thousand two hundred and seven, the number of deaths being one thousand three hundred and sixty-six. The disease, therefore, did not assume an epidemic form, the total number of cases scarcely exceeding those of two or three days in the former attack. Why the difference? A new water supply from the neighboring mountains was introduced shortly before 1865, but the better water had not yet come into general use. A satisfactory system of drainage was provided at the same time, though the proper disposal of the sewage had not been attained. The sewers opened just outside of the city limits as then existing. Houses, however, have since been built farther out, and it is interesting to notice that a majority of the cases of last year occurred in this portion of the town. The authorities at the time of the outbreak of the disease in 1885, promptly closed all of the old fountains with one exception, the supply for which was carefully guarded. The new water is of excellent quality, and is conducted to the city in a series of magnificent works, and is immediately distributed from covered reservoirs, cisterns not being in use. During the existence of the disease in the vicinity, the uncovered portions of the aqueduct were rigidly guarded, no one being allowed to approach without a permit.

---

* *Nature*, June 17, 1886, p. 149.

Seville at the last census had 134,000 inhabitants, and one may say has no drainage at all. Cess-pools are constructed outside of the houses (usually under the streets), into which the sewage passes. One part of the town, inhabited mostly by the poorer classes, 30,000 in number, is supplied from the river Guadalquivir. The Guadalquivir is fed above the city by the Rivers Darro and Genil flowing through Granada, a province in which, as we shall see, the disease was epidemic during the months of July, August and September. The main part of the town is supplied with water from underground springs about nine miles to the eastward, whence it is carried in covered conduits to the city. This water is excellent. It cannot be said that Seville is ordinarily a healthy city, typhoid fever being exceedingly common and the death rate very high; but on June 14, previous to the outbreak of the disease in the neighboring provinces, the city authorities prohibited the use of water from the river for any purpose whatever, and in the suburb above mentioned the spring water was introduced. No one was allowed to approach the springs, which were guarded day and night. The cholera raged in Granada during the summer. It descended the river Genil, and town after town upon its banks became victims to the ravages of the disease. The invaded territory formed a circle about Seville. Yet the town itself escaped. Nine cases were known to occur in houses not connected with the water supply, but information is wanting as to what water was used. The disease did not spread and was soon exterminated.

Malaga, a city of 116,000 inhabitants, is in a worse condition in regard to its drainage than Seville. The older part of the town has narrow, filthy streets, and the climate in summer is exceptionally favorable for the existence of the disease; but Malaga has, during the last few years, been provided with excellent spring water, brought to the city in pipes. Rigid precautions were taken to have no other water used in the city. Attempt has been made to prove that no real cholera existed in Malaga, but some two or three hundred cases are reported. The disease did not become epidemic, though in former visitations the city severely suffered.

Toledo, with 17,600 inhabitants, was supplied with water from the river Tagus flowing through provinces severely afflicted with the virulent disease, above the city, but by way of precaution the authorities stopped the pumps and obliged the inhabitants to procure water from distant springs. There is no record of cholera in Toledo for the year.

Let us, however, see the other side of the picture. Granada, with a population of 76,000, is supplied with water from aqueducts furnished from the rivers Darro and Genil. These canals are uncovered, and exposed to contamination. Cholera broke out in July and made frightful headway. About the middle of August there were reported four hundred and fifty cases per day. The total number of cases up to the middle of September was 6,471, and the deaths, 5,093—over 6.5 per cent. of the population, against ½ per cent. in Madrid. Sometimes hundreds of corpses were lying in the cemetery waiting interment. The inhabitants were panic-stricken and the authorities paralyzed. No attempt was made to correct the water supply until the disease had become established. The course of the disease was easily followed down the river, the infected waters carrying death wherever used.

No case of cholera occurred in Valencia until the middle of May, though in the not distant territory it had been spreading during the two previous years. The water used is from the Turia, taken from the river three and one-half miles above the town. After being passed through sand filters it is stored in a covered reservoir, whence it is conducted to the city in iron pipes. The water remained in a good condition until infected in the upper portions of the river by the spread of the disease as noted, when it evidently carried the disease to the city, in which the ravages of the disease were afterward exceedingly great. By the end of June the number of cases had arisen to seven hundred daily; the total number of cases for four months was 4,234.

In Saragossa, with 84,500 people, the disease became epidemic, and the number of cases during the summer amounted closely to 10,000. The principal water supply is derived from the famous canal of Aragon, long used for navigation and irrigation. This is fed from the river Ebro, fifty miles above. Some of the inhabitants, however, obtain their water directly from the Ebro, which flows past the older portion of the city; others use the waters of the Jalon. That from the canal is stored in reservoirs and afterward passed through charcoal filters. For some time before the commencement of the disease in the city the cholera existed in small towns along the banks of these rivers, affording abundant opportunity for the contamination of the water, which had no other protection than that of the filters. The waters of the Jalon did not even have this, and this supply was ultimately cut off by the authorities, with a notable decrease in the disease.

After numerous other citations, our author states that such illustrations may be indefinitely multiplied, all going to show the primary importance of the purity of the water supply, whether drainage and sewerage are as they should be or not. Toledo, Seville and Malaga were certainly in bad sanitary conditions, except that the water was secure from infection, and these towns conspicuously escaped any serious loss from cholera, while other towns mentioned, which were otherwise in conditions quite as favorable for health, suffered severely. Cities supplied with water from springs, and secured from contamination, were the freest from cholera. The information shows that dependence cannot be placed upon filtration of the water, as we see that at Saragossa, where the charcoal filters were used, and at Valencia, where sand-filters were used, the disease nevertheless was epidemic. The only security evidently consists in obtaining waters absolutely free from infection, as at Seville, and, as after the stringent governmental order, at Toledo. This account lends new confirmation to the correctness of the conclusions of Koch, the renowned German investigator, that the disease is due to a specific organism capable of multiplying outside the body, and, taken in connection with the other proofs adduced, makes it well-nigh certain that the co-called "komma bacillus" is this specific disease germ.

Leaving this suggestive history let us attend to a wonderful story of accomplishments in quite another direction. The one name upon people's lips just now, not only in our own country but throughout the civilized world, is that of Pasteur. Indeed, in one enthusiastic paper recently written, the author says that the nineteenth should be called the century of Pasteur. His culminating work, as we all know, is that upon hydrophobia, in which it is assumed that he has obtained a method of protective vaccination against this frightful malady. It will be interesting here to pause a few moments upon a description of the man, referring to the writings of those who have recently been with him, especially Drs. Sternberg,* Beggs† and Billings,‡ of our country, and G. M. Crawford,§ of England.

Here he is in his office. Everything is plain and commonplace. There are shelves filled with tubes, vials and retorts; there are tables, microscopes and apparatus; there are books and papers in unglazed cases, and the other appurtenances of a scientist's surroundings. It is an early hour in the forenoon. The man sits with his face to the window, opening letters and telegrams, sorting and arranging, filing these, throwing those into a large waste-basket at his side. He is earnestly engaged in his work, heedless of the numerous eyes staring upon him through the window. As he rises we see that he is short in stature—five feet six or seven inches in height—with straight, black hair a little sprinkled with gray, short-trimmed whiskers, a large head, the bronzed complexion of a military veteran and the face of a soldier, somewhat recalling the familiar pictures of General Grant. The countenance is a grave one, indicative of earnest thought rather than of the emotional character we so frequently attribute to Frenchmen. The eyes are of a pecular topaz-yellow, and often stare directly forward as if at vacancy, lighted up now and again by flashes of inspiration and the promise of high achievement. His movements are not altogether free and easy, especially those of the limbs of one side—the result of an attack of paralysis some years since. He is not much of a talker. His conversation is direct and simple, very rarely enthusiastic; yet indications are not wanting of a fine and tender emotional quality which shows itself in his acts as well as his words. He is sixty-three years old.

The clock strikes half-past ten. Pasteur rises from his seat and going to the hall-door invites the waiting candidates for inoculation to enter. The names are called from the ledger and the designated persons pass one by one to Dr. Grancher for the inoculation. The doctor uses a needle-pointed hypodermic syringe, which is thrust under the skin, and the contents are gradually injected. The patients are called by Pasteur in the order of their arrival, so that each receives the virus of the proper strength. The man is kind and bustling, with ready sympathy for the timid. If a little one sobs or whimpers, some trinket or coin is produced from the waistcoat pocket, which, with the accompaniment of a pat upon the head, is given the little one as an assurance of kindness.

---

* *Medical News*, XLVIII. (1886), p. 449.

† *Medical News*, XLVIII. (1886), p. 383.

‡ *Medical News*, XLVIII. (1886), p. 86.

§ *Fortnightly Review*, XXXIX. (1886), p. 9.

Now, let us examine the results of the peculiar treatment.

According to the latest statistics at command, closing April 22, 1,335 persons had been vaccinated according to the progressive treatment adopted by the renowned investigator,—thirteen from America. Each patient receives ten to fourteen inoculations on as many successive days.

In a lecture by Dr. Grancher,* Pasteur's medical adviser and colleague before mentioned, the persons bitten and vaccinated were arranged in three classes:

First.—Those bitten by a dog of which the spinal chords were sent to Pasteur's laboratory, inoculated in rabbits, and caused death of the latter by hydrophobia; or those who had been bitten by a dog, the bite of which had caused death by hydrophobia in other animals or man.

Second.—Those bitten by a dog, which before or after death, had been examined and declared rabid by a veterinarian.

Third.—Those bitten by a mad dog which had escaped observation.

In the first group there were ninety-six patients, of which one died. In the second six hundred and forty-four subjects and three deaths, a mortality for the two of 0.75 per cent.

It is asserted according to the best statistics that 16 per cent. of those bitten by rabid animals die, a showing in favor of Pasteur's treatment not to pass unheeded. The third series, though still more favorable, is not discussed because little dependence can be placed upon the reality of the disease. The mortality among patients bitten on exposed surface (the face and hands) was in the first group, one in fifty-four or 1.8 per cent.; in the second group three in four hundred cases, or 0.75 per cent.

---

* *Medical News*, XLIX. (1886), p. 110. *Science*, VIII. (1886), p. 95.

M. Brouardel, in examining the statistics of the Council of Hygiene, of Paris, from 1862 to 1872, finds that in non-vaccinated persons bitten on exposed surfaces, the mortality is 80 per cent.

In addition, Pasteur has vaccinated forty-eight persons bitten by mad wolves; of these seven have died, giving a mortality of 14 per cent. Brouardel has shown that non-vaccinated individuals similarly bitten present a mortality of 66.5 per cent.

If the efficacy of the rabic vaccine be compared with that of the charbon vaccine and the Jennerian lymph, it is found that the three agents have practically the same value. Before the introduction of the Jennerian vaccination, out of 1,000 small-pox patients, 500 died, while after its introduction but twenty-three out of 1,000 vaccinated persons succumbed. The value of Jennerian vaccine is, therefore, 500 to 23 equals 21.7 to 1. Similarly for *charbon*. Before the use of Pasteur's vaccine the mortality was 120 per 1,000, while at present out of 1,000 vaccinated animals but five die. The value of the *charbon* vaccine, is, therefore, 120 to 5 equals 24 to 1. In rabies, before the method of vaccination, the mortality was 160 per 1,000, while after vaccination the deaths were 7 per 1,000. The value of antirabic vaccine is, therefore, 160 to 7 equals 22.85 to 1. That is, these various vaccinations saved about twenty-two out of twenty-three patients, who would otherwise hopelessly die of the specified diseases. Of course it will be remembered that prophylactic vaccination against small-pox prevents a far greater percentage of cases of disease.

The antirabic vaccination by Pasteur has been very differently commented upon. He has been denounced as an enthusiastic fanatic and extolled as the most eminent and beneficent genius of the century. When, however, we carefully examine the records of facts and assure ourselves of the painstaking fidelity with which they are compiled, when we ascertain to our satisfaction the sincere and honest character of the renowned investigator, we cannot help but ascribe to him the profound gratitude of our hearts. When we remember the frightful character of hydrophobia as a disease, the hopelessness of treatment, the utter paralysis of medical skill in presence of the unknown agent of the affliction, and of the agonies of the sufferer, we cannot avoid, we would not avoid, joining with hearty voices in the ringing plaudits of praise to the man who has robbed the disease of its terror, and who daily gives hope and joy to those who were otherwise doomed to die most miserably, or to suffer even worse tortures of mental distress and gloomy forebodings.

Pasteur has been most unjustly charged with keeping his method secret. Nothing can be further from the truth. He has fully published his processes, and has generously given instruction to several qualified surgeons, and magnanimously furnished them with his prepared materials. In gratitude for his achievements, the city of Paris has given him land, and donations are rapidly accumulating from all quarters for a large international hospital for his use, named the "Pasteur Institution." Pasteur hospitals are also in process of founding in Italy, Austria, Russia and America, each having already received the modified virus and methods of operation from Pasteur himself.